Volume I.] *May, 1900.* [*No. 3.*

BIOLOGICAL BULLETIN.

THE EARLY CLEAVAGE AND FORMATION OF THE MESODERM OF SERPULORBIS SQUAMIGERUS CARPENTER.

S. J. HOLMES.

THE material upon which the present paper is based was collected at San Pedro, Cal., in the summer of 1895. Work upon it was carried on for a time during the winter of 1895–96, under Prof. C. O. Whitman, at the University of Chicago; but as the series of stages the material afforded proved incomplete, the subject was laid aside in the hope that, at some future time, when new material could be collected, the gaps might be filled. Since it is improbable that an opportunity of remedying this defect will soon present itself, and as the development of this form shows several interesting points of comparison as regards the formation of the mesoderm with what has recently been found to obtain in other mollusks and certain annelids, it was thought best to publish the present account. The development of Vermetus, a genus from which Serpulorbis is somewhat doubtfully distinct, has been studied by Salensky[1] in considerable detail. According to Salensky, mesoblastic pole cells do not appear, and the mesoderm in Vermetus arises at a comparatively late period of development by a proliferation from the ectoderm in the region of the blastopore. With this conclusion my own observations do not agree, as certain stages that were found afford very clear evidence that the mesoderm arises

[1] *Archives de Biologie.* I, vi, 1887.

from the posterior macromere *D*, as has been found in so many other cases among mollusks and annelids.

Serpulorbis squamigerus is a common mollusk on the coast of southern California. The shell early loses all traces of its originally spiral form, and becomes bent and twisted in a very irregular way. Many individuals are often found tangled together, resembling a group of worm tubes, and forming masses of considerable size. The eggs are deposited in elongated capsules attached by one end a short distance within the mouth of the shell. In addition to the eggs the capsules contain numerous small cells, probably follicular, which doubtless serve to nourish the developing embryos. A large number of the eggs in each capsule fail to develop normally, and sooner or later break up into masses of isolated blastomeres. The cleavage of such eggs is irregular, sometimes from the start, but often the irregularity appears only after the egg has developed for some time in an apparently normal manner. As this departure from the typical path of development occurs at different stages in different eggs, it is not always easy to distinguish the normal from the abnormal process of cleavage.

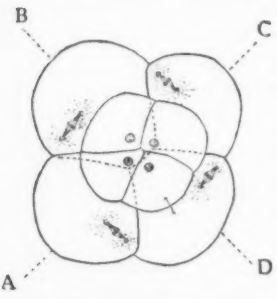

FIG. 1. — Eight-cell stage, seen from the animal pole. The dexiotropic origin of the first quartette of micromeres is indicated, and the spindles in the angles of the macromeres show that the next division will be laeotropic.

The first two cleavages are total and equal, giving rise to a four-cell stage of the usual molluscan type, in which two cells meet in a cross furrow at the vegetal pole. The next cleavage, which results in the formation of the first generation, or quartette, of micromeres, is dexiotropic. The micromeres are rather small, as is the rule in molluscan eggs, in which, as in the present case, there is a large amount of yolk. At the next cleavage the second quartette of micromeres are given off from the macromeres in a laeotropic direction. The spindles appear at one angle of the macromeres, but before the next division the nuclei wander through the cell so that the spindles next

appear at the opposite angle. The same migration is repeated in an opposite direction in preparation for the next ensuing division. The appearance of the second quartette is soon followed by a laeotropic division of the cells of the first. A dexiotropic cleavage of the second quartette next appears, and at about the same time the macromeres bud off the third quartette in a right-handed spiral, completing the separation of the ectoderm from the entoderm. The twenty micromeres composing the ectoderm are all transparent and devoid of yolk. While they form about one-half the surface of the egg, they

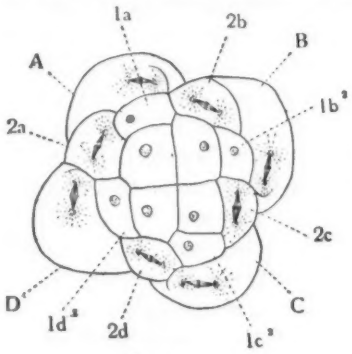

FIG. 2.

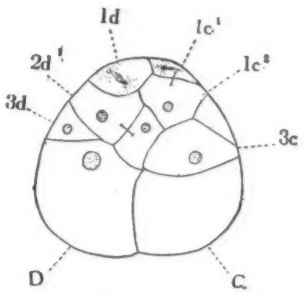

FIG. 3.

FIG. 2. — Sixteen to twenty-four cell stage from the animal pole, showing the origin of the third quartette and the dexiotropic cleavage of the second. The first quartette has divided, producing the four "trochoblasts."

FIG. 3. — Lateral view of the twenty-four cell stage. A cleavage is taking place in the apical cells.

form much less than half its bulk, as their thickness is not nearly so great as that of the large yolk-laden entomeres. The conclusion drawn by Salensky, that in Vermetus there are four quartettes of micromeres produced, is doubtless erroneous. The cleavage of the first quartette of ectomeres was probably overlooked, and the outer products of this division regarded as having had a separate origin from the macromeres. A comparison of Salensky's figures with the cleavage of Serpulorbis renders this interpretation probable. Besides, there are strong reasons for doubting that four generations of ectomeres are ever produced among the gasteropods, as I have attempted to show elsewhere.

The next cleavage occurs in the macromere *D*, and results in the formation of a yolk-laden cell, lying obliquely above the larger stem cell in such a way as to indicate that the division was laeotropic. This cell corresponds exactly as regards its time and mode of origin with the primary mesoblast cell of other mollusks. The corresponding division of the other three macromeres to form the remainder of the fourth quartette does not occur until a considerably later period. These divisions do not give rise to ectomeres, but to large yolk-laden entomeres, the cells of the fourth quartette being somewhat larger, if anything, than those at the vegetal pole.

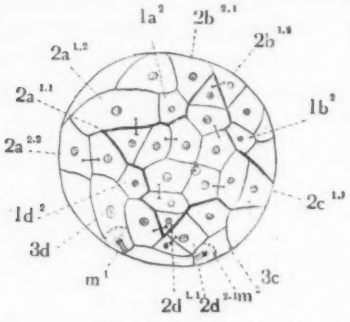

FIG. 4.— Forty-eight-cell stage, seen from the animal pole. The outline of the cross is marked with a heavier line. A dexiotropic twist is apparent in the arms of the cross. The small mesoblast cells are shown in dotted lines on the posterior side of the egg.

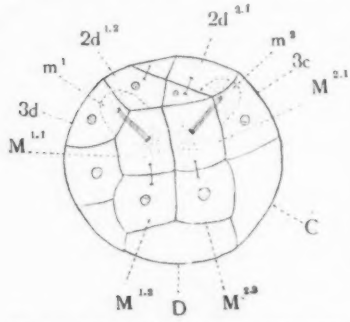

FIG. 5.— Posterior side of the same egg, showing the four derivatives of 4*d*, the upper pair budding off the mesomeres, m^1 and m^2, into the interior of the egg.

About the time the primary mesoblast cell is given off the four apical cells of the first quartette divide in a dexiotropic direction, the outer products of the division forming the basal cells of the arms of the cross. Up to this time the cleavages of Serpulorbis agree, point for point, with those of Crepidula, Lymnaea, Limax, Planorbis, and Physa, with the exception that the divisions in the latter two genera are reversed. A comparison of the forty-eight-cell stage, shown in Figs. 4 and 5, indicates that the following divisions have taken place: The four upper cells of the second quartette have divided in a laeotropic direction, giving rise to the cells $2a^{1.1}$, $2b^{1.1}$, etc., which

form the tip cells of the arms of the cross. The four tip cells are smaller than the others, as in Crepidula and Planorbis. A cleavage of the four lower cells of the second quartette has taken place, likewise in a laeotropic direction. The second quartette now contains sixteen cells in four groups of four cells each. These cells bear exactly the same relations to each other, to the arms of the cross, and to the adjacent cells of the other quartettes, that they do in Crepidula, Planorbis, and several other forms at the corresponding stage of development. There can be no doubt, therefore, of their derivation, though their actual divisions were not all observed. The large entomeres, *A*, *B*, and *C*, have divided laeotropically, completing the formation of the fourth quartette. In place of the mesoblast cell 4 *D* there is a group of four cells, an upper pair containing little yolk, and a lower pair of about the same size in which the yolk is abundant. The origin of these cells was not followed, but there can be little doubt that they all owe their origin to the mesoblastic pole cell. They occupy the same area that was occupied by the pole cell. The cap of ectodermic cells is radially symmetrical, and contains no cells of sufficient size to have given rise to such large cells as the upper pair of the four without altering very materially the symmetrical relations shown in the figure. Besides, nothing corresponding to such a division is seen in other forms. In all probability these cells arose first by a horizontal division of the mesoblast cell, such as occurs in a large number of forms, and then by a division of the two daughter-cells in a plane at right angles to the previous one. At this period the egg contains a regular cap of ectodermic cells, four entomeres at the vegetal pole, three entomeres, 4 *a*, 4 *b*, and 4 *c* of the fourth quartette, and the group of four cells above described, in place of the remaining cell of the fourth quartette, 4 *d*. A comparison with the corresponding stage in the egg of Crepidula, as shown in Fig. 31 of Conklin's paper,[1] shows that the cells of the ectodermic cap correspond point for point, and also *that the four cells we have derived from 4 d are represented in Crepidula by four cells of subequal size having the same origin and position.* The fourth quartette is formed a

[1] *Journ. Morph.* Vol. xiii. 1897.

little later in Crepidula than the stage shown in Fig. 31, otherwise the two eggs are practically identical. The four cells in Serpulorbis are all on the surface of the egg and are not overlapped so much by the ectomeres as in Crepidula. The upper pair in Fig. 4 is shown in process of division. Each cell buds off a small cell into the interior of the egg, the spindles diverging anteriorly. At about the same period an almost exactly similar division occurs in Crepidula, the upper pair of cells budding off a small cell into the interior of the egg in very nearly the same direction. At a somewhat later stage in Serpulorbis, shown in Fig. 6, I have found two pairs of small cells lying entirely within the cleavage cavity which probably represent the descendants of the single pair whose origin has just been described. The parallelism with Crepidula extends also to this division as the corresponding pair of small cells in that form divides at about the same period. This is as far as the cleavage of these cells was carried. These results were worked out before Conklin's paper appeared, and as I did not follow the further history of these cells, as Conklin has succeeded in doing in Crepidula, it seemed uncertain what interpretation of them should be made. It seemed improbable that all of 4 *d* should form the mesoblast, as it was supposed to do in several forms. The four large cells showed no signs of passing into the interior of the egg, and it is probable that, after the mesoderm is separated from the upper pair, they enter into the formation of the entoderm, as in Crepidula.

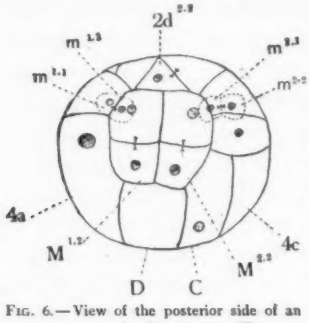

FIG. 6.—View of the posterior side of an egg in a somewhat later stage. There are seen two pairs of mesomeres in the cleavage cavity.

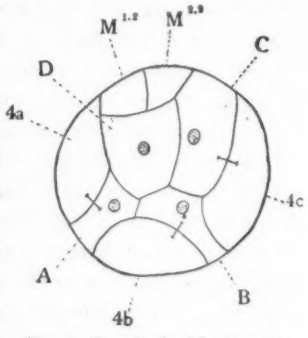

FIG. 7.—Vegetal pole of the same egg shown in Fig. 5.

Recent researches render it probable that the cell 4 *d* is not typically a purely mesoblastic cell. As Conklin has pointed out, the divisions of 4 *d* in Umbrella are strikingly like those in Crepidula, and strongly indicate, as Conklin maintains, that this cell contains both mesoderm and entoderm. The same cell in Cyclas was held by Stauffacher[1] to produce both mesoderm and entoderm. In Unio, Lillie[2] found that the pole cells budded off small cells at the surface before giving rise to the mesoblastic bands, and among annelids similar phenomena have been observed by Mead[3] in Amphitrite, by Wilson[4] in Nereis and Aricia, and by Treadwell[5] in Podarke. In Planorbis[6] I have found that a minute cell is budded off from each of the pole cells before they divide to form the mesoblastic bands. It has been suggested by Wilson that these minute cells correspond to the small entomeres found in Nereis, but they are budded off in a different direction and lie in the cleavage cavity instead of on the surface. This does not prove, however, that they are not homologous with entodermic cells, as a slight change in the direction of division of the pole cells would bring them in the wall of the blastula. And as they are probably not functional they may represent the last vestige of the entodermic portion of the mesentomeres.

[1] *Jen. Zeit.* Bd. xxviii. 1893.
[2] *Journ. Morph.* Vol. x. 1895.
[3] *Journ. Morph.* Vol. xiii. 1897.
[4] *Ann. N. Y. Acad. Sci.* Vol. xi. 1898.
[5] *Biological Lectures*, delivered at Woods Holl, Session of 1898, 1899.
[6] *Zoöl. Bull.* Vol. i. 1897.

NEW SPECIES OF HYGROCELEUTHUS AND DOLICHOPUS, WITH REMARKS ON HYGROCELEUTHUS.[1]

AXEL LEONARD MELANDER AND CHARLES THOMAS BRUES.

THE recognition of two new species of *Hygroceleuthus* and a study of both sexes of the other American species of this genus, and of another species which has been hitherto placed in *Dolichopus*, have shown the necessity of revising this genus. Hitherto but little attention has been paid to the females, which are very difficult to separate, whereas the males present very evident characters and are easily identified.

Previous to 1868 only one species of *Hygroceleuthus* was known from North America, and three others from the rest of the world. Since then North America has produced at least eight species, making it the richest country known in species of this genus.

Hygroceleuthus and *Dolichopus* are very closely allied, their separation being effected by male characters alone. These two genera form a group distinct from other *Dolichopodidae* by the presence of a number of bristles on the upper surface of the hind metatarsi. They have in common also the first joint of the antennae hairy above, third joint short, its arista dorsal, and hypopygium free.

The so-called distinction between the two genera is to be found in the length of the face which, in the typical males of *Hygroceleuthus*, is lengthened and attains the lower corner of the eye. Subordinate to this and even less constant are the lengthened antennae, deep incision in the hind margin of the wing, and broadened wings. In the three typical species of *Hygroceleuthus*, which have tarsal ornamentation, this occurs on the middle legs. In *Dolichopus* there is no species with the

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, under the direction of W. M. Wheeler, *No. 1.*

middle legs similarly ornamented if we except *plumipes*. For this reason and because it shows a tendency toward the lengthened face of *Hygroceleuthus*, we have included *plumipes* in the present paper. But as this species shows strong *Dolichopus* characters in the short, stout antennae and slight costal thickening, it cannot be placed satisfactorily in either genus as they have been defined. On the other hand, the European *Hygroceleuthus diadema* merges with *Dolichopus* on account of its shortened antennae.

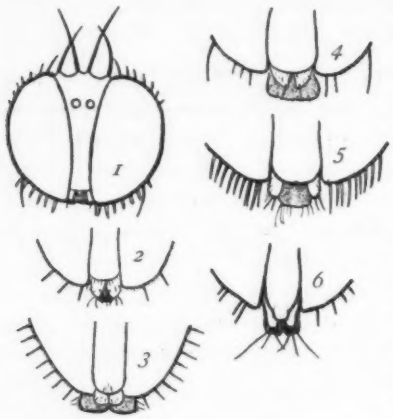

FIG. 1.—Showing length of face: 1, *Dolichopus comatus*, male; 2, *Hygroceleuthus plumipes*, male; 3, *Hygroceleuthus Wheelerii*, male; 4, *Hygroceleuthus amnicola*, female; 5, *Hygroceleuthus afflictus*, male; 6, *Hygroceleuthus latipes*, male.

The original definition of *Hygroceleuthus* included a deep incision in the hind margin of the wing and broadened wings. From these characters *Aldrichii* and *Wheelerii* deviate very decidedly.

Latipes, the only North American *Hygroceleuthus* which Loew saw, possessed no characters at variance with the typical species. It was because of limited material that Loew felt justified in constructing this genus. Like other genera founded on secondary sexual characters alone, such as *Rhagoneura* and *Spathochira* of this same group, *Hygroceleuthus* has been found invalid as the number of species increased.

From the foregoing it seems advisable that *Hygroceleuthus* be no longer retained with generic value, but may be kept as an expression for a group of the genus *Dolichopus*.

Of the previously described species of *Hygroceleuthus*, one has failed to be recognized, *lamellicornis* Thom., if indeed this be a species of *Hygroceleuthus*. The type was a female from California, but the description omitted the important points.

We have examined types of all the species except *latipes*, *plumipes*, *crenatus*, *afflictus*, and *ciliatus*. The specimens studied in the preparation of this paper are in the collection of Dr. Wm. M. Wheeler, who kindly placed his collection at our disposal.

Although the name *ciliatus* has been previously used by Walker,[1] Aldrich's *ciliatus* may remain, as Walker's species is too poorly characterized to admit of its recognition.

Males.

Middle tarsi ornamented 2
Middle tarsi plain 5
2. Antennae largely black . . . . . *Aldrichii* Wheeler
First joint of antennae yellow 3
3. Middle tarsi strongly compressed . . . . . *latipes* Loew
Middle tarsi not compressed, first joint feathered laterally . . 4
4. Middle tibia twice length of femur . . . *Wheelerii*, sp. nov.
Middle tibia not elongated, slender . . . . *plumipes* Scop.
5. Cilia of tegulae yellow 6
Cilia of tegulae mostly black 8
6. Second abdominal segment laterally with a tuft of yellow hairs *afflictus* O. S.
Abdomen without such tuft 7
7. Face yellowish white . . . . . *crenatus* O. S.
Face silvery . . . . . *idahoensis* Aldrich
8. Arista bare . . . . . *ciliatus* Aldrich
Arista densely pubescent 9
9. Front coxae yellow, postocular cilia in part yellow *consanguineus* Wheeler
Coxae black, postocular cilia wholly black . . var. *propinquus*

Females.

First joint of antennae yellow 2
First joint of antennae in great part black 4
2. Species about 6 mm. first joint of middle tarsus yellow at base . 3
Species about 4 mm. Middle tarsi wholly black . . *plumipes* Scop.
3. Hind tibiae wholly yellow, vertex green . . . *latipes* Loew
Hind tibiae black at tip, vertex violet . . . *latipes* var. *cognatus*
4. Tip of hind tibiae black, or, if yellow, the wings narrow . . 5
Hind tibiae wholly yellow 6

[1] *List of Diptera in Collection of British Museum*, pt. iii, p. 661.

5. Front femora with the basal two-thirds infuscated *amnicola* sp. nov.
   Front femora wholly yellow . . . . . *Aldrichii* Wheeler
6. Arista with slight pubescence; wings usually with a stump-vein at the bend of the fourth vein 7
   Arista bare 8
7. Second joint of hind tarsi yellow at base; legs yellow; smaller species *crenatus* O. S.
   Second joint of hind tarsi black; legs darker; larger species *consanguineus* Wheeler
8. Tegular cilia wholly black, somewhat robust . . . *ciliatus* Aldrich
   Tegular cilia yellow at sides 9
9. Wings yellowish anteriorly, coxae yellow . . . *afflictus* O. S.
   Wings hyaline, coxae darker . . . . *idahoensis* Aldrich

Hygroceleuthus Wheelerii, sp. nov.

Male. Length 5 mm.; length of wing 4 mm. Shining metallic cupreous green. Proboscis piceous. Face covered with a thick dust, silvery on lower half, becoming golden towards antennae. Antennae yellow, first two joints wholly so, the third black on upper surface and outer half. First joint hairy above, and with a slight swelling on inner surface to meet the other antenna; second joint tipped with a fringe of black hairs, becoming stouter and longer on underside, nearly one-half the length of first joint when viewed from above. Third joint somewhat longer than the first, bearing dorsally a stout arista with very short pubescence. Vertex metallic violet. Postocular cilia delicate, black above and light yellow below. Thorax bright grassy green, becoming cupreous at sides and with a faint indication of the two narrow approximated median brown lines. Abdomen green, with silvery dust at sides and beneath. Posterior margins of segments becoming cupreous and margined with piceous. Hypopygium green, almost piceous, overlaid with a grayish dust. Lamellae pale, with a distinct narrow dark border and a black fringe. Internal appendages yellow. Sides of thorax glaucous; shining green when viewed from behind. Fore coxae yellow, hairy on whole anterior face and with a few bristles at tip. Middle and hind coxae yellow with outer face glaucous at basal two-thirds. Trochanters, femora, and tibiae yellow. Middle tibiae very long and thin, the proportion of femur to tibia of the middle leg being 20 to 39. Hind tibiae not incrassate, nor with smooth space on inner surface. Anterior tarsi black from tip of first joint, middle and hind tarsi black. Middle

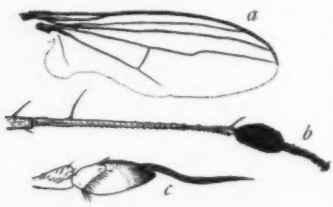

FIG. 2.—*H. Wheelerii*: *a*, wing of male; *b*, middle leg; *c*, antenna.

tarsi short, first joint broadly feathered laterally. Wings narrow, hyaline, distinctly yellowish towards costa. The usual costal swelling at tip of first vein is slight. Almost no incision at tip of fifth vein. The anal angle of wing is produced into a large distinct lobe. Veins dark. Bend in fourth vein regular. Halteres and tegulae yellow, the tegular cilia long and black.

One male specimen taken by Dr. Wm. M. Wheeler in a cranberry bog at Woods Holl, Mass., July 13, 1899.

This very distinct species is readily recognized by its lengthened middle tibiae. Aside from this the following are more or less characteristic: the reduced costal swelling and incision of the wing as well as the pronounced anal lobe; the peculiar lateral ornamentation of the middle tarsi, which are unusually short; the violet front; the light-colored antennae and finely pubescent arista; and the yellow hind tibiae.

Hygroceleuthus plumipes Scopoli.

Male. Length 3.5–4.5 mm. Length of wing 3.5–4 mm. Face yellow pollinose. Antennae yellow, third joint black at tip. First joint with a slightly prominent projection on its inner side. Arista slightly pubescent. Front metallic green. Thorax without distinct dusted bands. Abdomen

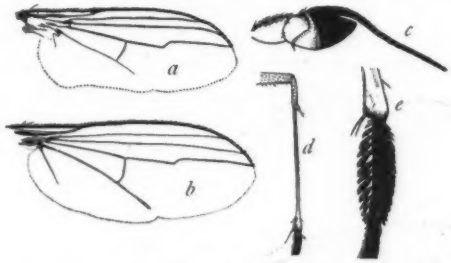

FIG. 3. — *H. plumipes*: *a*, male wing; *b*, female wing; *c*, antenna: *d*, middle tibia; *e*, middle metatarsus, male.

metallic green above and distinctly bronzed toward the apex; white dusted at the sides and covered throughout with short black hairs. Lamellae of hypopygium narrowly bordered with fuscous. Pleurae metallic green, covered with white dust. Coxae of same color as the pleurae, except the anterior ones, which are yellow and covered with black hairs on the anterior and inner surfaces, bearing also a few black bristles at their tips. Femora yellow. Tibiae yellow, the middle pair slightly, and the posterior pair distinctly tipped with black. Middle tibiae flat, very slender except at extreme

base and apex, which are normal in form. The flat sides each with a wide, shallow, piceous groove extending along the entire length of the tibia. Tarsi black, except basal two-thirds of anterior pair. Middle tarsi with the first joint longer than the two following and broadly feathered laterally. Wings narrow, the anterior and posterior margins subparallel, nearly hyaline. Swelling at tip of humeral vein slight, incision at tip of fifth vein slight. Tegulae with long black cilia.

Female. Length 3.5–4.5 mm. Length of wing 3.5–4 mm. Face broader, gray, greenish in certain lights and darker below. Middle tibiae and tarsi of the usual form. Anal lobe of wing more rounded than in the male, and the costa not thickened.

Twenty-three specimens examined. Sixteen males and six females, from Rabbit Ear Pass 10,000 feet, and North Park, 9000 feet, Colorado. Also one male specimen from Vancouver Island, collected by Mr. C. Livingston.

This species is readily distinguished by the peculiarly formed middle tibia and tarsus of the male. The female may be separated from *latipes* by its smaller size and wholly black middle tarsi, and from all the other species by the entirely yellow first antennal joint.

The distribution of this species is most interesting. It is one of the three species of *Dolichopus* which are common to Europe and North America. It is mostly a boreal species, being found in great numbers throughout Northern Europe, from Cape North to Switzerland. In America it was noticed by Loew from Alaska. Where *plumipes* extends toward the south it is limited to high altitudes, as witnessed in Switzerland and Colorado.

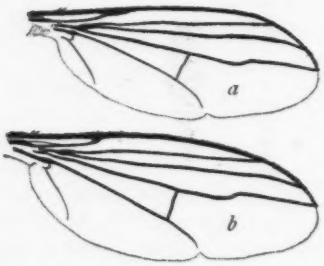

FIG. 4.—*H. latipes*: *a*, male; *b*, female.

Hygroceleuthus latipes Loew.

Male. Length 5–7 mm., of wing 4.5–6.5 mm. Face silvery, yellowish above. First joint of antennae yellow, at most slightly darkened above, long. Arista pubescent. Vertex generally green. About 6 to 8 of the supraocular cilia black, the remainder pale. Abdomen with posterior margins of the segments cupreous. Lamellae of hypopygium white with narrow black border and fringe. Anterior coxae yellow, hairy on distal

portion in front. Femora and tibiae yellow. Middle tarsi compressed, ornamentation dorsal on last four joints. Wings thickened at tip of first vein and incised at fifth. Tegula cilia black, a few yellow inside.

Female. Face silvery, broader. Antennae shorter, first joint hairy above, sometimes infuscated above. Vertex green. Abdomen more cupreous, and anterior and middle tarsi slightly lighter than in the male. Posterior femora with two macrochaetae near tip on outer side. Wing incision not very deep.

This species has a greater distribution than any of the other species, except *plumipes*. It has been taken at various places in the Northern States from Connecticut to Idaho. This is the commonest species, and, aside from *Wheelerii*, the only species yet found east of the Dakotas.

Latipes, var.? *cognatus*. Two specimens vary from the type as follows and may possibly represent another species. Posterior tibiae black at tip and hind tarsi totally black. Vertex violet. Posterior femora each with only one macrochaeta on outer side near apex. One female from Woods Holl, Mass., July 19, 1899, and another female from Pullman, Ill., August 7, 1897.

Hygroceleuthus Aldrichii Wheeler.

Male. Length 4–5 mm. Face with silvery white dust below, ochreous above. Antennae black, first and second joints yellow below on mesial surface. Arista moderately pubescent. Front green. Postocular cilia white on lower two-thirds, black above. Lamellae of hypopygium yellow with black border and fringe of delicate black hairs. Anterior coxae yellow, others dark. Second, third, and fourth joints of middle tarsi distinctly compressed and fringed with stout black hairs. Anal angle of wing bilobed, costal thickening prominent and incision at tip of fifth vein slight. Tegulae with long black cilia.

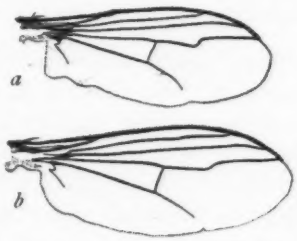

FIG. 5.—*H. Aldrichii*: *a*, male; *b*, female.

Female. Length 4–5.5 mm. Face grayish-yellow. First joint of antennae almost entirely black. Tip of hind tibiae usually black. Incision at tip of fifth vein slight. Anal angle not bilobed, and tarsi but very slightly compressed.

Numerous specimens examined, males and females. From Idaho, Wyoming, and Colorado.

The peculiar anal lobe of the male wing easily identifies this species. The female is not so easily distinguished, but can be recognized by the characters given above.

Hygroceleuthus amnicola, sp. nov.

Female. Length 4.5 mm., of wing 4.5 mm. Of a bright metallic green with cupreous reflections. Palpi light yellow with black hairs. Face evenly overlaid with golden dust. Antennae black with lower half of first and second joints yellow. The difference in color is sharply marked. First joint hairy above, with a rather large yellow projection from inner side. Second joint tipped with a fringe of black hairs which are longer below. Front metallic brassy green. Upper half of the postocular cilia black, lower pale. Thorax shining green, not much dusted in front, disc somewhat cupreous; the two narrow approximated lines are left green. Sides of thorax glaucous, becoming more piceous in all the coxae. Front coxae with black hairs on whole anterior face. Middle and hind femora yellow; fore femora black for nearly proximal two-thirds. All the tibiae yellow, infuscated at tip; the darkening especially prominent on the hind legs. Front tarsi black from tip of first joint; middle tarsi with first and second joints yellow, their tips black, remaining joints black; hind tarsi black from base of first joint. Wings long and narrow, greatly prolonged beyond tip of fourth vein; the fourth vein with a very strong bend and continued obliquely forward. Halteres and tegulae yellow, the cilia of the latter long and black.

FIG. 6.—*H. amnicola*: wing of female.

One specimen, Colorado, Grizzly Creek, North Park; collected by Mr. C. F. Baker.

Although this species is represented by a single female specimen, it is so distinct that there is no hesitancy about its position. The wings reach further beyond the fourth vein; the angle of the fourth vein is more nearly rectangular; the coxae are darker and the femora blacker than in any other female *Hygroceleuthus*.

Amnicola differs from *Aldrichii* thus: middle tarsi are not compressed and are largely yellow; the front femora and coxae are much darker; the wings are hyaline and more extended beyond the veins, and the fourth vein is more sharply bent.

Hygroceleuthus crenatus O. S.

Male. Length 5–6 mm. Face yellowish-white. Antennae with the two basal joints black, except a yellow protuberance on the inner side of each. Arista densely pubescent. Postocular cilia black on upper third, yellow below. Anterior coxae yellow, with a black stripe outwardly. Femora and tibiae yellow; the hind tibiae incrassate, with a shallow, broad, brownish groove on the inner side. Anterior and middle tibiae infuscated toward the tips. Hind tarsi black except base of first joint. Lamellae of hypopygium nearly white, margined with black at the tips. Wings very broad, narrowed to the base. Costa moderately thickened, incision at tip of fifth vein moderate. Cilia of tegulae yellow, delicate, sometimes with a few black hairs intermixed.

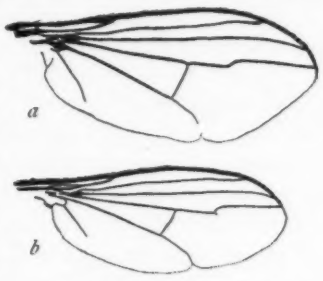

FIG. 7. — *H. crenatus*: *a*, male; *b*, female.

Female. Length 5–6 mm. Face uniform gray. First joint of antennae in great part black. Arista black, slightly pubescent. Hind tibiae wholly yellow, the hind tarsi with the second joint yellow at the base. Wings with a distinct incision at tip of fifth vein. A stump-vein projecting from the bend of the fourth vein, sometimes abbreviated.

Numerous male and female specimens examined from California, Washington, Wyoming, Idaho, and Vancouver Island.

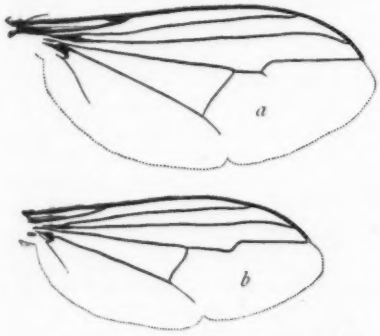

FIG. 8. — *H. consanguineus*: *a*, male; *b*, female.

Hygroceleuthus consanguineus Wheeler.

Male. Length 5.5–6.5 mm., of wing 4.5–5.5 mm. Upper two-thirds of face more opaque than lower third, generally with two broad vertical bands on upper two-thirds. Antennae black, in small part yellow below, and on mesial surface of first and second joints. First joint with smooth swelling inside. Arista thick, densely pubescent. Postocular cilia black, becoming thick and flat below; upper infraorbital cilia bright orange, lower black. Lamellae of hypopygium

piceous with suffused black border. Legs yellow, black from tip of first tarsal joint. Hind tibiae incrassate slightly. Distal portion of fourth vein with abrupt angle and with stump-vein. Cilia of tegulae black.

Female. Somewhat smaller and with relatively longer wings. Stump-vein at angle of fourth longitudinal present. Tegular cilia black. Fore coxae with black hairs in front. The dilation of first antennal joint is less prominent. The lower postocular cilia are also parti-colored but less flattened than in the male.

This species was described from a large number of specimens collected in July, 1896, near Monterey, Cal.

Consanguineus, var. *propinquus*. Several interesting specimens received from Mr. C. Livingston, from Corfield, Vancouver Island, vary from the typical *consanguineus* as follows:

Darker. All the coxae piceous; femora piceous beneath near base. Postocular cilia black, none of the orange-colored cilia of the typical *consanguineus* present, not so many of the infraocular cilia flattened. Lamellae of hypopygium darker.

Hygroceleuthus afflictus O. S.

Male. Length 6–6.5 mm. Face white, silvery. Antennae with yellow expansion on inner side of first joint; second joint with only a vestige of yellow on the inner side. Pubescence of arista sparse but robust. Vertex green. Postocular cilia black above for a long distance, descending nearly to the middle of the eye; below light yellow. Second abdominal segment bearing on each side near the middle a tuft of long yellow hairs, directed backward and reaching to the middle of the fourth segment. Third segment with a very small similar tuft. Hind tibiae incrassate, with a broad shallow groove on the inner side. Costal thickening and incision at fifth vein of wing distinct.

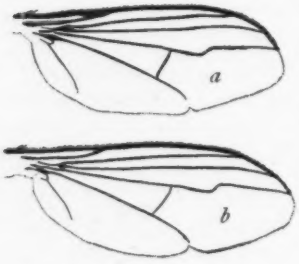

FIG. 9. — *H. afflictus*: *a*, male; *b*, female.

Female. Length 5.5–6.5 mm. Face gray, with a greenish tinge on the lower part and slightly ochreous near the base of the antennae. Antennae dark, first and second joints in great part black. Arista bare. Abdomen without any tufts of yellow hair. Anterior coxae yellow, sometimes with a small posterior stripe dark. Hind tibiae completely yellow. Wings yellowish anteriorly, costa not thickened, notch at tip of fifth vein very pronounced. Tegular cilia black, yellow at the sides.

Numerous males and females examined from Arizona, Monterey County, Cal., and Wyoming. It was described from San Rafael, Cal., and is recorded also from Washington.

The male of this species is very easily known by the presence of the tufts of yellow hair upon the second abdominal segment.

Hygroceleuthus ciliatus Aldrich.

Male. Length 4–5.5 mm. Face yellowish-white. Front green. Antennae black, except lower half of first and second joints. Arista bare. Post-ocular cilia black on upper third, below nearly white. Sides of first abdominal segment with a few white hairs. Tips of hind tibiae blackish. Tarsi simple, black from tip of first joint. Wings narrow, hyaline, costa not thickened at tip of first longitudinal. Indention at tip of fifth vein slight. Tegulae with long black cilia.

Female. Length 4–5.5 mm. Face yellowish-gray. Arista of antennae bare. Hind tibiae wholly yellow. First joint of hind tarsi lighter at base. Tegular cilia black. Wings with a distinct incision at tip of fifth vein.

Numerous specimens examined from South Dakota and Wyoming.

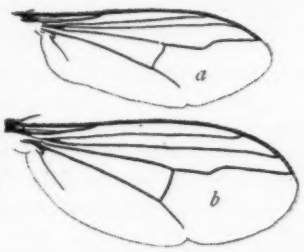

FIG. 10.—*H. ciliatus*: *a*, male; *b*, female.

Hygroceleuthus idahoensis Aldrich.

Male. Length 5.2 mm., of wing 4.8 mm. Face silvery. Antennae black, not large but with swollen yellow protuberance on inner side; second joint slightly yellow on inner side; arista rather stout. Vertex blue-green. Lamellae of hypopygium small, white, with rather wide black margin. Anterior coxae yellow with a dark green stripe on outer face, and with a few hairs on lower part. Hind tibiae incrassate with a longitudinal depression. Tarsi black from tip of first joint. Costa thickened for a long distance, the incision in hind margin slight. Tegular cilia pale, not large.

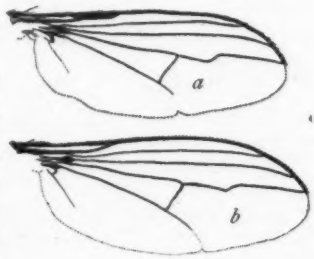

FIG. 11.—*H. idahoensis*: *a*, male; *b*, female.

Female. Face broader, darker than in the male. Anterior coxae more hairy. Wings less yellow anteriorly, costa not thickened. Tegular cilia larger, black with a slight admixture of pale ones.

Moscow, Idaho. September. The original collection numbered about seventy-five specimens.

LIST OF THE SPECIES OF THE GROUP HYGROCELEUTHUS.

plumipes Scopoli, 1763. *Ent. Carn.*, 334.
latipes Loew, 1861. *Neue Beitraege*, Fasc. viii., 5.
? *lamellicornis* Thomson, 1868. *Eugenies Resa*, 511.
crenatus Osten Sacken, 1877. *Western Diptera*, 312.
afflictus Osten Sacken, 1877. *Western Diptera*, 313.
ciliatus Aldrich, 1893. *Kan. Univ. Quart.*, 25.
idahoensis Aldrich, 1894. *Kan. Univ. Quart.*, 154.
Aldrichii Wheeler, 1899. *Proc. Cal. Acad. Sci.*, 3.
consanguineus Wheeler, 1899. *Proc. Cal. Acad. Sci.*, 5.
Wheelerii Melander and Brues, *sp. nov.*
amnicola Melander and Brues, *sp. nov.*

Dolichopus.

The following notes and descriptions were made from specimens belonging to Dr. Wm. M. Wheeler, who has not only given us his entire collection to work over, but has also tendered us much aid and advice.

The appended list is given in the hope that it may prove useful, as it contains many new localities. It is interesting to note that so many of Loew's species have been again recognized.

Dimorphism has not been noticed in the genus *Dolichopus* as yet, but a most interesting case of what may turn out to be such is to be found in the species *Henshawi* and *marginatus*. Of the more specific characters these two species possess in common the following: antennae similarly colored, vertex violet, fore coxae with dark hairs, hind tibiae with similar dark glabrous stripes, similar wing neuration, and the yellow hind femora of the male ciliated with black hairs, in which character they differ from all other dolichopodes. On the other hand, the males seem evidently distinct as follows:

Henshawi. Face generally yellow; postocular cilia darker yellow; fore tibiae incrassated at tip; fore tarsi ornamented and banded; hind tibiae not evidently darkened towards tip

except a large black blotch on inner side; lamellae of hypopygium fringed with comparatively short hairs.

Marginatus. Face gray; all the legs plain; front tarsi gradually darker toward tip; hind tibiae more infuscated at apex; lamellae fringed with numerous longer hairs.

The females of these species cannot be separated. They agree rather with *marginatus* in the color of the postocular cilia and of the legs. The males, evidently so distinct, were taken, together with the females, in the same netful at Woods Holl, Mass., by Dr. Wheeler. *Marginatus* is the commoner form. In all were taken from July 14 to August 9, 1899, forty-eight females, thirteen male *Henshawi*, and nineteen male *marginatus*.

Dolichopus partitus, sp. nov.

Femora chiefly black, cilia of inferior orbit black, wings infuscated, coxae wholly black.

Male. Length 5–5.5 mm., of wing the same. Dark green with metallic lustre. Proboscis and palpi black. Face rather wide, short, concave beneath the antenna, and with a pronounced transverse ridge at its lower fourth, below this convex. Face covered with light brown pollen, except a small spot at each side of the ridge. Antennae totally black; the first joint with short bristles above; the bristles about the apex of the second joint much longer below. Third joint short, ovate, obtusely pointed at tip; arista black, pubescent. Front dark violaceous green. Postocular cilia totally black. Thorax above, dark green, with a median longitudinal dark cupreous band. Scutellum of same color as thorax. Abdomen metallic green, lighter than thorax. Surface covered with short black hairs, more sparse towards base; very slightly covered with whitish dust. Hypopygium almost black, shining with two patches of black hair on dorsal side near the base; internal appendages ferruginous. Lamellae yellow, of usual size, with a black border. Between the white center and black border is a ferruginous band. The border is very much jagged at apex and furnished with strong bristles, becoming more slender towards base. Pleurae greenish-black, covered with whitish dust; coxae black. Legs black, except femora and tibiae just at their articulation, the four anterior tibiae and the base of the first joint of four anterior tarsi. Posterior femora not ciliated. Wings infuscated about cross-vein and at apex between costa and third vein. The

FIG. 12. — *D. partitus*: male wing.

latter spot reaches only to the second longitudinal in one specimen. Veins black; costa with an elongate swelling at the junction of the humeral vein; notch at tip of fifth vein distinct. Tegulae and halteres light yellow, the former with long black cilia.

Described from two male specimens collected in North Park, Colorado.

This species is related to *Johnsoni* Aldrich, but may be distinguished by its wide face, totally black coxae, spotted wings, and violaceous front.

Dolichopus paluster, sp. nov.

Bluish-green; antennae totally black; infraocular cilia black; tegular cilia black; legs including coxae black; tarsi not ornamented; hind femora ciliated in male.

Male. Length 5–5.5 mm. Wing 4.5–5 mm. Shining bluish-green. Proboscis and palpi piceous. Face moderately wide, between three and four times as long as the width at the middle, covered with brownish-yellow pollen, not at all silvery. Vertex dark blue-green. Postocular cilia all black. Antennae totally black; first joint with but few bristles above, those about the apex of the second joint very long below. Third joint oval, obtuse at apex. Arista black, pubescent, about twice as long as the antenna. Dorsum of thorax dark green, tinged with blue. In some specimens there is a median stripe, more blue and shining. Scutellum of the same color as thorax, fringed with short light-brown hairs. Abdomen green, distinctly bluish in many specimens, and very shining, sharply compressed towards apex and somewhat inflated near the base; destitute of light dust. Hypopygium black, shining, slightly ochreous-dusted near the base, and bearing a bunch of black hairs basally. Lamellae oval, slightly angulated inwardly, nearly white, with a sharply defined black border, fringed with black bristles which are more delicate basally. Internal appendages dark ferruginous. Pleurae black, white dusted, those of the prothorax green like the dorsum. Legs, including coxae, wholly black, fore coxae white dusted, and with short black hairs. Anterior tarsi not ornamented, about one-fourth longer than the tibiae; middle tarsi but slightly longer than tibiae. Hind femora ciliated on apical half with black hairs, the longest hairs not longer than the width of the femur at the point of their insertion. Posterior tibiae somewhat thickened. Wings grayish; veins black; costa but slightly thickened at tip of first longitudinal; fourth vein not sharply bent, approximated with the third vein at tip. Incision at tip of fifth vein slight. Tegulae and halteres yellow, tegular cilia black.

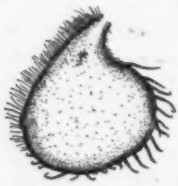

FIG. 13.—*D. paluster*: male lamella.

Female. Size same. More coppery than the male, especially on the sides of the thorax and abdomen. Face dark yellowish-gray; slightly more than twice as long as wide. Posterior femora not ciliated below, hind tibiae not thickened. The wings are brownish, darker anteriorly between the costa and second longitudinal; the veins black, very narrowly margined with brown. Otherwise like the male.

Described from five male and four female specimens, collected by Dr. Wm. M. Wheeler, in Monterey County, Cal., during July, 1896.

This species is most closely related to *corax* Osten Sacken, from which it differs as follows: lamellae nearly white, bordered with black; fore tarsi male plain. In *corax* the front tarsi are ornamented and the lamellae are nearly black, yellowish-brown in the middle only.

Dolichopus intentus, sp. nov.

Femora largely black; tibiae pale; cilia of inferior orbit dark; tegular cilia dark; wings hyaline; lamellae of hypopygium small, dusky; antennae black, third joint long, pointed, with subapical arista.

Male. Length 4 mm., of wing 3.5 mm. Dark bronzed green dusted. Proboscis dirty yellow, palpi piceous. Face thickly covered with silvery dust, except a small median spot immediately below antennae. Antennae black; first and second joints subequal; first two joints more or less shining, densely clothed with appressed short pubescence; third joint more opaque, the pubescence closer. First joint bristly; second joint with a terminal fringe of bristles which become longer beneath; third joint longer than first and second together. Arista subterminal, shorter than third antennal joint. Front violet, metallic, slightly bronze dusted. Postocular cilia black. Thorax and abdomen greenish-bronze above, becoming piceous dusted below. Hypopygium piceous dusted, shining inwardly. Internal appendages dark; lamellae small, fuscous without a distinct darker border, fringed with hairs only. Legs plain, dark, with usual bristles. Front coxae somewhat lighter than pleurae, yet silvery. Femora piceous except the yellow tip; hind femora with two ante-apical bristles. Fore and

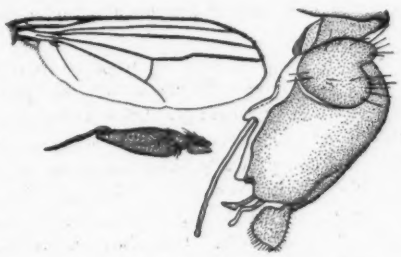

FIG. 14. — *D. intentus*: male wing, antenna and hypopygium.

middle tibiae yellow; hind tibiae black at tip, slightly swollen along middle, but without a smooth space internally. Wings subquadrate, hyaline, third and fourth veins subparallel at tip. Wings with costa at tip of first vein thickened and without an obvious notch at terminus of fifth vein; anal angle rounded. Tegulae and halteres yellow. Tegular cilia black.

One specimen, collected by Dr. Wm. M. Wheeler at Chicago, Ill., dated May 8, 1896.

This species is allied to *laticornis* Loew, and *incongruus* Wheeler, but is at once distinct in the structure of the antennae.

In his table of *Dolichopus*,[1] Mr. Aldrich commits *incongruus* to the section with the femora yellow. The type specimen has dark legs. Division 5 of his table may be thus altered:

5. Third joint of antennae large 5*a*
Third joint as usual, tegular cilia black 6
5*a*. Tegular cilia yellow; hind tibiae dark on whole under surface
incongruus Wheeler
Tibiae of hind legs infuscated towards tip 5*b*
5*b*. Tegular cilia generally yellow; lamellae of hypopygium clear
laticornis Loew
Tegular cilia black; lamellae of hypopygium dusky
intentus nov.

Dolichopus calainus, sp. nov.

Femora chiefly black, cilia of inferior orbit pale, middle tibiae black, femora yellow only at extreme tip, hind femora not ciliated, legs wholly black.

Male. Length 5 mm., of wing 4.5 mm. Bright metallic blue with greenish reflections. Proboscis and palpi piceous. Face of usual length and rather narrow; light gray below, ochreous and darker above. Antennae totally black, third joint ovate, obtusely pointed at tip. Arista black, moderately pubescent, nearly twice as long as the antenna and inserted about the middle of the third joint. First joint but slightly bristly above, more strongly so toward the tip. Front bright blue with a decided greenish tinge. Postocular cilia black above, below the middle light. Just before the lower corner of the eye they are suddenly somewhat longer and placed very close together, forming a sort of brush. Dorsum of thorax and scutellum deep shining blue, greenish only at extreme sides and in front. Abdomen much compressed toward the apex; shining bluish-green, whitish dusted on the sides below and covered with black hairs, which grow longer toward the apex of the abdomen. Hypopygium piceous, with several conspicuous

[1] *Kan. Univ. Quart.* Vol. ii., No. 1, p. 2.

patches of black hairs; internal appendages light brown. Lamellae small, strongly infuscated, lighter at middle; with a narrow black border which is much wider on the lower corner; fringed with black bristles which are slender, especially on the upper edge. Pleurae very dark green, grayish dusted. All the coxae black. The anterior ones silvery in front and covered with short black hairs. Legs black, slightly whitish dusted. The anterior tibiae dark brown on the inner side. All the femora at extreme tip, the tibiae at extreme base and the first joint of anterior and middle tarsi at extreme base, yellow. Wings hyaline, the veins black. Costa with a knot-like swelling at junction of humeral vein. Tegulae and halteres yellow, the former with long black cilia.

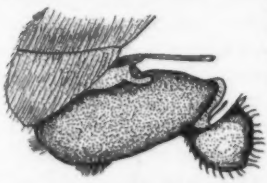

FIG. 15.—*D. calainus:* hypopygium.

Described from one male specimen collected by Dr. Wm. M. Wheeler in Chicago, May 8, 1896.

This species is related to *myosota* O. S., but may be distinguished by the lamellae of the hypopygium, which are larger, darker, wider, and distinctly angulate below.

Dolichopus enigma, sp. nov.

Dark green, shining; wings brownish in front; tegular cilia black; cilia of inferior orbit pale; femora black, hind pair of male not ciliated; fore tibiae brownish-yellow; lamellae of hypopygium subrectangular.

Male. Length 4 mm., of wing 3.5 mm. Bright green, not very shining. Proboscis and palpi piceous. Face rather wide, covered with dense silvery dust, brownish in certain lights. Antennae totally black, sericeous, but little hairy above. First joint long, second and third taken together, about twice the length of first. Arista less than twice as long as antenna, black, but little pubescent. Front dark green, not very shining. Postocular cilia black above and pale below. Dorsum of thorax and scutellum bright green, somewhat cupreous in front. Abdomen dark green, bronzed, not so bright as thorax; covered with black hairs throughout and white dusted on sides and below. Incisures between segments black. Hypopygium

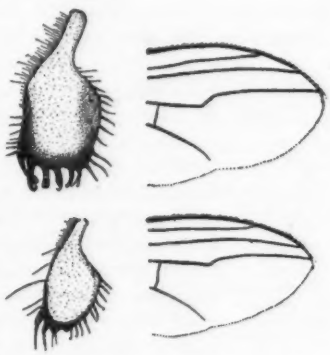

FIG. 16.—*D. enigma*, male; *D. ovatus*, male.

black, basal portion opaque, white dusted, with two patches of black hair dorsally ; towards the apex very shining. Internal appendages ferruginous. Lamellae subrectangular, dirty, translucent, white, with brown border, wider at apex, where it is jagged and bristly. Pleurae very dark green, opaque, white dusted. Legs, including coxae, totally black, except the anterior tibiae above and the base of anterior tarsi, which are more or less yellow above, femora indistinctly tipped with brownish-yellow. Tarsi not ornamented, hind tarsi with the usual bristles. Wings grayish, tinged with brown in front and along the veins ; costa with a short swelling in the angle which it makes with the first vein ; bend in the fourth vein not very abrupt ; second and third veins much approximated except at tip ; no distinct incision at tip of fifth vein. Tegulae and halteres yellow ; tegular cilia black.

One male, North Park, Colorado, over 9000 feet, collected during July.

This is closely related to *ovatus* Loew, but is distinct by the much larger subrectangular lamellae, costa with a swelling, second and third veins more approximated, and wings brownish in front.

Dolichopus agronomus, sp. nov.

Femora chiefly black, cilia of inferior orbit pale, middle tibiae yellow, first joint of hind tarsi with few bristles, hind femora ciliated with short hairs.

Male. Length 3.5 mm., of wing 3 mm. Dark metallic green. Proboscis and palpi piceous. Face very long, densely covered with bright silvery pollen, which continues past the antennae as far as the frontal bristles. Above the antennae it is greenish-white and not so dense. Antennae long, totally black, the first two joints short, the third large and broad, elongated ovate and rather sharply pointed. Arista black, pubescent, a little longer than the antenna. Postocular cilia black above, pure white below. Thorax bluish-green, covered with very fine white dust. A median shining stripe is not at all dusted. Abdomen very strongly compressed toward apex, dark green, white dusted, especially along the sides. The extreme basal and apical margins of the segments more or less free from the dust. Entire abdomen covered with short black hairs. Hypopygium black, shining, covered at base with white dust. Internal appendages light yellow. Lamellae nearly white with an indistinct narrow blackish border ; elongate oval. Each lamella nearly bilaterally symmetrical, but little angulate inwardly and beset with the usual bristles. Pleurae greenish-black, dusted with gray. Coxae of same color as the pleurae, all tipped with yellow, the

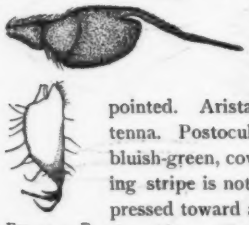

Fig. 17.—*D. agronomus*: male antenna and lamella.

anterior ones silvery in front. Femora brownish-black, tipped with yellow. Anterior and middle tibiae yellow, the anterior ones lighter. Posterior tibiae and tarsi deep black, the former yellow at extreme base. Anterior and middle tarsi blackened from the tip of first joint. Wings oval, much narrowed toward the base, hyaline, the veins dark brown. Costal swelling and incision at tip of fifth vein not well marked. Tegulae and halteres yellow. Tegular cilia yellow, with a couple of strong black ones intermixed.

Described from one male specimen, collected by Dr. Garry deN. Hough, at New Bedford, Mass., June 8.

From *convergens* it differs by the vertex being white pollinose, as well as the face. Also the hind femora are ciliated with short hairs; the hind tibiae are totally black; the lamellae of the hypopygium are oval, and the third and fourth veins of the wing converge less strongly.

From *albiciliatus* it differs by the smaller size; longer third antennal joint, and the black hind tibiae. Moreover, the ciliation of the hind femora of the male is shorter; the lamellae are not broad and rounded, and are much lighter in color.

From *xanthocnemus* it can be readily distinguished by the shorter ciliation of the hind femora and the black hind tibiae.

This is a very peculiar species and superficially resembles the species of the group *Hygroceleuthus*, although it is otherwise quite different.

Dolichopus pernix, sp. nov.

Green; face whitish; antennae black, arista plain; infraocular cilia white; tegular cilia black; feet yellow, including fore coxae, tip of hind tibiae conspicuously black; last two joints of male fore tarsi moderately enlarged, black; fourth longitudinal vein not broken.

Male. Length 4.75 mm., of wing 4.5 mm. Green, shining. Proboscis piceous, palpi yellow. Face narrow, silvery white, flavescent towards antennae. Antennae wide, black, first joint dark brown below; joints subequal; second and third together ovate; third obtusely pointed; arista dorsal, sericeous, longer than antenna, inserted at middle of third joint. Vertex shining green. Postocular cilia except upper five white. Thoracic dorsum green, more or less shining, towards front and sides brassy. Abdomen shining green, sparsely silvery dusted above, becoming thickly at sides and below, cupreous towards tip. Hypopygium piceous, dusted, greenish towards base, shining on inner surface. Lamellae elongate,

FIG. 18.—*D. pernix*: male antenna and tip of fore tarsus.

light yellow, narrowly margined with black, fringed with dark hairs, inner and apical angle prolonged into several long filaments. Pleurae glaucous, in different parts green, cupreous or piceous, according to angle of vision. Middle and hind coxae piceous, glaucous. Fore coxae yellow, piceous and dusted basally on posterior face; front surface besides the strong apical bristles with fine dark hairs which are supplanted by lighter ones on proximal portion. Legs yellow except apex of hind tibiae, hind tarsi, and last two joints of front tarsi. The middle and front tarsi increase in density of color from tip of first joint. Hind femora not ciliated, with a subterminal bristle. Hind tibiae not glabrous inwardly. Front tarsi slender, as are the tibiae, nearly twice the length of the tibiae; first joint longest, a little shorter than two following; second and third subequal, fourth shortest, fourth and fifth together about equal to third; fourth and fifth joints flattened. Empodia distinct, yellowish. Wings long, hyaline; costa with a small tubercle at juncture of first vein; third vein converging towards fourth; bend in fourth vein slight; at tip of fifth vein a broad, shallow sinus; anal portion moderately prominent. Tegulae and halteres yellow, the former with long black cilia.

One male taken by Mr. Clermont Livingston at Corfield, Vancouver Island, May 21, 1896.

Though closely related to *discifer*, it appears quite distinct. The more evident points of difference are these:

Pernix: First antennal joint not red beneath; arista inserted near middle of third joint of antenna; numerous dark hairs on anterior face of fore coxae; tip of hind tibiae evidently black for some distance; fourth tarsal joint flattened, black; wings not evidently narrowed at base.

Discifer: First antennal joint reddish on under side; arista beyond middle of third antennal joint; front coxae with white hairs (dark hairs on inner side of female, only); hind tibiae dark at only extreme tip and less on outer side; fifth tarsal joint only black; wings rather narrowed towards base.

The proportion of the tarsi to the tibiae is also different, as is also the comparative length of the tarsal joints.

Dolichopus pantomimus, sp. nov.

Green; face narrow, light brown; antennae black with simple arista; cilia of inferior orbit pale; cilia of tegulae black; feet yellow, including front coxae and excepting tip of hind tibiae and tarsi, not ornamented in the male excepting femoral brush; fourth vein not broken.

Male. Length 4 mm., of wing 3 mm. Bright metallic green, somewhat brassy. Proboscis piceous, palpi ferruginous at tip with few dark hairs. Face very narrow, with eyes almost contiguous at middle, thickly overlaid with ferruginous dust, shining. Antennae black, sericeous, not noticeably bristly; second joint closely applied to the third; first joint equal to second on inner side; third joint long, pointed, equal to first two together. Arista finely pubescent, arising from middle of upper surface of second and third joints taken together. Vertex green, shining. Infraocular cilia white. Thorax with dorsum bright green, cupreous anterior to wing insertion, dusted in front; with an indication of two brown median longitudinal lines in front. Abdomen dorsally bright green, cupreous tinged; the posterior margins of segments blackened. Hypopygium wholly piceous, somewhat shining, and finely sericeous. Lamellae in length equal to antennae, white translucent, with a jagged, moderately wide black apical border, and closely fringed with black hairs at tip. Pleurae, sides of abdomen, and base of posterior fore coxae dark green, glaucous. Fore coxae wholly yellow, rather sparsely beset with pale hair, besides the apical bristles. Legs plain, yellow; hind femora with an ante-apical bristle and ciliated below with not long yellow hairs; hind tibiae stouter than the others, and with a long glabrous streak on hind surface, black at tip for one-seventh its length; hind tarsi entirely black, anterior pairs darker towards tip, but not black. Empodia very small, silvery. Wings narrow, tinged somewhat dark gray; costa, at tip of first vein, with an evident knot; fourth longitudinal vein not broken; hind margin entire at tip of fifth vein; anal angle rather strong.

FIG. 19. — *D. pantomimus*: male antenna and lamella.

A single male from New Bedford, Mass., collected May 30, by Dr. Garry deN. Hough.

Related to Loew's *melanocerus*, but differs in the smaller size, color of the hairs of the fore coxae, which are not black at base, anterior tarsi not black, and the narrowed darker face.

Dolichopus renidescens, sp. nov.

Green; shining; face broad, light brown, antennae black, with a plain arista; vertex violet; cilia of inferior orbit white, of tegulae black; legs yellow, except tips of the tarsi and hind legs from outer portion of hind tibiae, not ornamented except the ciliation of hind femora; fourth vein not broken.

Length 4.5–5 mm., of wing the same. Bright green, shining, darker on thoracic dorsum, almost bluish. Proboscis piceous, palpi brunneous. Face

broad. Antennae dull black, sericeous, short, with slender, dark, sericeous arista, once and a half the length of the antenna; third joint a little shorter than the first two together, broadly oval, rounded but obtusely pointed at apex; second joint with circlet of hairs. Front violet. Upper seven of postocular cilia black, rest pale yellow. Thoracic dorsum bluish-green, brilliantly shining except for indications of longitudinal dusted rows; scutellum and ante-scutellar region purer green. Abdomen shining green, with brassy tinge, lightly dusted. Pleurae glaucous on a green foundation. Middle and hind coxae, except tip, and extreme base of fore coxae of same color as pleurae. Front coxae with black pubescence on anterior face. Legs largely yellow, the hind femora with two ante-apical bristles; fore and middle legs dark from tip of first tarsal joint; hind tarsi black, hind tibiae infuscated at tip. Wings hyaline, normal, a slight sinus at tip of fifth longitudinal. Tegulae yellow with rather long black cilia. Halteres yellow.

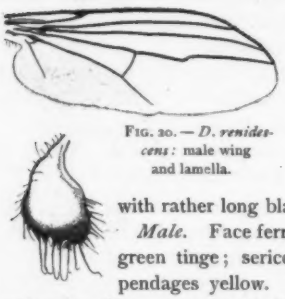

FIG. 30. — *D. renidescens*: male wing and lamella.

Male. Face ferruginous. Hypopygium piceous with brassy green tinge; sericeous below, shining inwardly; internal appendages yellow. Lamellae clavate, broad, white translucent, rather broadly margined with black at extremity, apex jagged and fringed with rather long, slender, nearly straight, black hairs. Hind tibiae with a long, narrow glabrous streak, more evident near tip, on hind face. Anal angle of wing full; costa thickened at junction with humeral vein.

Female. Face with gray dust. First antennal joint a little longer than in male. Hind tibiae not glabrous, the apical infuscation not evident. Anal angle of wing rounded; costa not thickened.

Two males and one female from North Park, Colorado, collected at an altitude of over 9000 feet during July.

The shorter antennae, broader face, violet front, more extended margination of hypopygial lamellae, and the closer ciliation with brown hairs of the hind femora which possess two ante-apical bristles, distinguish this species from *melanocerus* Loew.

Dolichopus apheles, sp. nov.

Green; face ochraceous; antennae black, with a simple arista; infra-orbital cilia white; tegular cilia black; feet plain, yellow, except tips of hind femora and tibiae black; hind tarsi black; fore coxae yellow with dark hairs; fourth longitudinal vein not broken.

Male. Length 5 mm., of wing 4 mm. Not so brightly colored as in most species, largely green. Proboscis piceous, palpi roseous yellow. Face

ochraceous. Antennae sericeous, black, except underside of first joint, which is indistinctly reddish, very like those of a female *Hygroceleuthus;* first joint longer than second, short, hairy above ; second with a crown of black bristles ; third short, deep, subtriangular. Arista sericeous. Vertex blue green in certain lights, violet in others, somewhat shining. Infraocular cilia pale ; six of the supraocular cilia black. Thorax dull, bluish on dorsum ; posterior declivity and scutellum shining green. Abdomen shining green dorsally, cupreous toward apex, transverse margins of segments piceous. Hypopygium piceous with greenish tint, shining, and not sericeous on inner face ; lamellae rounded, rather short, white translucent, with a narrow, black, apical border, jagged and fringed with black hairs. Pleurae glaucous, as are the middle and hind coxae, except tips. Front coxae yellow with a basal glaucous-piceous spot on the outer side ; front surface with a coating of short black hairs, besides apical bristles. Legs yellow, entirely unornamented ; the darker places are : hind tarsi and outer fourth of hind tibiae black, tip of hind femora more evidently on upper surface black ; the infuscation of fore and middle tarsi begins at middle of first joint. Hind femora with a single ante-apical bristle and not ciliated beneath ; hind tibiae with no evidently glabrous space. Wings normal, rather dusky anteriorly ; without costal thickening at tip of first vein ; fourth vein unbroken, beyond bend gradually converging with third, but almost subparallel with it ; no indention in posterior margin ; anal angle full. Tegulae and halteres yellow, tegular cilia black, rather short and stout.

FIG. 21. — *D. apheles:* male lamella.

One male collected by Dr. Wm. M. Wheeler near Milwaukee, Wis., June 28, 1895.

This unique species is allied nearest to those species grouped about *melanocerus* Loew and *incisuralis* Loew.

The addition of the last four species has necessitated the following modification of Divisions 52 to 56 of Professor Aldrich's table.[1]

52.	Front legs of male ornamented	2
	Front legs plain	3
2.	Fourth joint of fore tarsi of male not flat . . .	*discifer* Stan.
	Fourth joint of fore tarsi of male flat, black . .	*pernix* sp. nov.
3.	Antennae wholly black ; hind femora of male ciliated . . .	4
	First antennal joint lighter below	6
4.	Front coxae with light hairs	*pantomimus* sp. nov.
	Front coxae with dark hairs in front	5

[1] *Kan. Univ. Quart.* Vol. ii, No. 1, p. 5.

5. Face rather narrow; front green . . . . *melanocerus* Loew
   Face broad; front violet . . . . . *renidescens* sp. nov.
6. Femora of hind legs of male ciliated, not blackened 7
   Male hind femora not ciliated, black at tip . *apheles* sp. nov.
7. Front coxae with black pubescence 8
   Front coxae with white pubescence . . . *platyprosopus* Loew
8. Bristles of hind tibiae long . . . . . *setosus* Loew
   Bristles of hind tibiae normal . . . . *incisuralis* Loew

56. *praeustus*, etc.

Dolichopus amphericus, sp. nov.

Light green; antennae yellow, except third joint and tip of second; fore tarsi ornamented; femora yellow; postocular cilia pale below; tegular cilia black, hind tibiae not black at tip.

Male. Length 6.5–7 mm., of wing 5.5–6 mm. Light coppery green with much white dust. Proboscis piceous, palpi testaceous. Face of medium width, about four times as long as broad, thickly covered with brilliant yellow dust. Front shining green. Antennae rather elongate; first joint yellow, with many short black hairs above; second joint yellow at base, becoming black at apex; third joint black, sericeous, obtusely

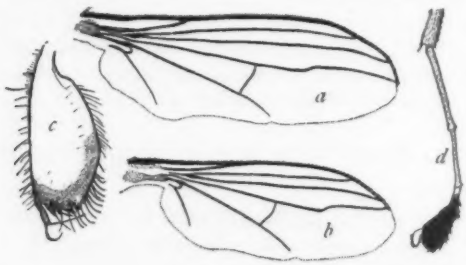

FIG. 22.—*a*, *D. amphericus*, male wing; *b*, *D. coloradensis*, male wing; *c*, *D. amphericus*, lamella; *d*, *D. amphericus*, male fore tarsus.

pointed at apex. Arista less than twice as long as antenna, very distinctly pubescent. Postocular cilia black above and light yellow on lower three-fourths. Thorax light green, coppery on the disc; slightly opaque by the presence of light yellow dust. Dorsally there is a deep coppery longitudinal stripe. Abdomen shining green, white dusted. The white dust is so thick as to obscure the ground color on the lower part of the sides. Incisures coppery. Hypopygium black, shining, except at base, where it is white dusted. Near the base bearing a large patch of black hair. Internal appendages ferruginous; lamellae very pale yellow, with a wide, sharp border of black at apex, where they are bristly and deeply toothed. Outer tooth bearing at its tip a strong, curved bristle. Pleurae greenish-black,

white dusted. Fore coxae yellow with white pubescence in front, at apex and inwardly with black hairs. Middle and hind coxae of same color as the pleurae, yellow only at extreme tip. The middle pair with white hairs in front. Legs yellow. Fore tarsi ornamented; the first two joints long and slender, first about once and a half the length of the second; third less than one-half the length of the first, much enlarged at apex, where it is infuscated; fourth joint small, shorter than the third, flattened, velvety black; fifth oval, about one-half as long as the first, broadly compressed, deep black and fringed on anterior edge with black hairs; empodia silvery white. Middle tarsi infuscated from tip of first joint. Hind femora not ciliated; hind tibiae wholly yellow with a dorsal, apical, glabrous stripe; hind tarsi wholly black. Tegulae and halteres yellow; tegular cilia black. Wings narrow, nearly hyaline, slightly brownish in front; costa with no noticeable swelling; fourth vein not broken; distinctly lobed at tip of sixth vein.

Female. Length 5.5–6.5 mm., of wing 6.25–6.75 mm. Face yellowish-gray. Front tarsi plain, infuscated from tip of first joint, the second and third joints lighter at base, giving the tarsus a somewhat banded appearance. Wings darker and longer than in the male; only a faint indication of the preanal lobe.

Two males and three females from Price County, Wis.; collected by Dr. Wm. M. Wheeler.

This species resembles *coloradensis* Aldrich, from which it differs by the larger size, bright yellow face, lighter antennae, brownish wings, and white hair on front face of anterior coxae.

Together with *flagellitenens* Wheeler, *amphericus* possesses greatly enlarged metapleurae which give a winged appearance to the first abdominal segment. The posterior portion of the metapleurae is dull black and pubescent.

The following localities are those of species in the collection of Dr. Wm. M. Wheeler:

Group *Hygroceleuthus.*

latipes Lw. Wisconsin, Illinois.
var. *cognatus*, Illinois, Massachusetts.
Aldrichii Wheeler. Idaho, Wyoming, Colorado.
plumipes Scop. Colorado. Vancouver.
Wheelerii M. *et* B. Massachusetts.
amnicola M. *et* B. Colorado.
crenatus O. S. Vancouver, California, Washington, Wyoming, Idaho.
consanguineus Wheeler. California.
var. *propinquus*. Vancouver Island.
afflictus O. S. Arizona, California, Washington.
ciliatus Ald. Wvoming, South Dakota.
idahoensis Ald. Idaho.

Group *Dolichopus*.

partitus M. *et* B. Colorado.
paluster M. *et* B. California.
laticornis Lw. Wisconsin, Wyoming.
intentus M. *et* B. Illinois.
incongruus Wheeler. Wisconsin.
gratus Lw. Illinois, Wisconsin.
calcaratus Ald. Massachusetts.
detersus Lw. Illinois, Wisconsin.
myosota O. S. California.
calainus M. *et* B. Illinois.
acuminatus Lw. Illinois, Wisconsin.
ovatus Lw. Wisconsin.
enigma M. *et* B. Colorado.
setifer Lw. Wisconsin, Massachusetts.
albiciliatus Lw. Massachusetts, Illinois, Wisconsin.
agronomus M. *et* B. Massachusetts.
xanthocnemus Lw. Vancouver Island.
pachycnemus Lw. Massachusetts.
longimanus Lw. Wisconsin, Massachusetts.
albicoxa Ald. Massachusetts, Illinois.
brevimanus Lw. Massachusetts, New Hampshire.
socius Lw. Massachusetts, New Jersey, Wisconsin.
palaestricus Lw. Illinois, New Hampshire.
splendidus Lw. Ontario, Michigan, Illinois.
splendidulus Lw. Illinois, New Hampshire.
batillifer Lw. Massachusetts.
tonsus Lw. Massachusetts.
tener Lw. Wisconsin.
variabilis Lw. Illinois, Wisconsin.
lutiepennis Lw. Vancouver Island.
bifractus Lw. Massachusetts, Illinois, Nebraska.
obcordatus Ald. Wyoming, Idaho.
ramifer Lw. Illinois, Texas, Wyoming.
vittatus Lw. Illinois, Wisconsin.
cuprinus Wied. Illinois, Wisconsin, Wyoming.
longipennis Lw. Vancouver Island.
flagellitenens Wheeler. Illinois, Wisconsin.
comatus Lw. Massachusetts, Illinois, Wisconsin.
pernix M. *et* B. Vancouver Island.
melanocerus Lw. Massachusetts.
pantomimus M. *et* B. Massachusetts.
renidescens M. *et* B. Colorado.
apheles M. *et* B. Wisconsin.
setosus Lw. Massachusetts, Vancouver Island.
gracilis Ald. Wisconsin.
angustatus Ald. Massachusetts.
lobatus Lw. Illinois, Wisconsin, Michigan.
coloradensis Ald. Colorado.
amphericus M. *et* B. Wisconsin.
Henshawi Wheeler. Massachusetts.
marginatus Ald. Massachusetts, New Jersey.
scoparius Lw. Massachusetts, Illinois, Wisconsin.
canaliculatus Thomson. California.
duplicatus Ald. Idaho.
Coquilletti Ald. Idaho, Vancouver Island.
tenuipes Ald. Idaho, California.
occidentalis Ald. Idaho, Vancouver Island.
scapularis Lw. Wisconsin.
germanus Wheeler. Wisconsin, Wyoming.
grandis Ald. California.
sexarticulatus Lw. Illinois, Louisiana.
Willistonii Ald. Kansas.
terminalis Lw. Wisconsin.
sarotes Lw. Wisconsin.

ON THE ORIGIN OF THE SPERM-BLASTOPHORE OF SOME AQUATIC OLIGOCHAETA.

SHINKISHI HATAI.

THE first investigator to discuss the origin of the sperm-blastophore in Oligochaeta was Bloomfield.[1] His work was done mostly on living material, although he supplemented it to some extent by preparations mounted in glycerine. He studied the external features only. Later, Calkins[2] published a detailed account on the same subject, his views being opposed to those of Bloomfield. Both of these writers made their observations upon Lumbricus terricolae. A more complete statement of their respective views will be given on a later page.

In the Limicolae the origin of the sperm-blastophore has not yet been studied, although some work on the structure of Limnodrilus Gotoi[3] and Vermiculus limosus[4] of this group has been published recently. These species are common in Japan. The material used in the present study was fixed in Perenyi's fluid and corrosive sublimate. The stains used were Kleinenberg's haematoxylin, Rawitz's haematoxylin, and borax carmine.

The present article deals only with the formation of the sperm-blastophore. The various stages in its development may be described advantageously in the following order:

1. *Spermatogonia.*—A section of the testis (Fig. 1) shows three stages in the maturation of the spermatogonia, namely: (*a*) The cells at and near the proximal end of the testis are

[1] Bloomfield, E., "On the Development of the Spermatozoa. 1. Lumbricus," *Quart. Journ. Micr. Sci.* Vol. xx. 1880.

[2] Calkins, G. N., "The Spermatogenesis of Lumbricus," *Journ. of Morph.* Vol. xi. 1895.

[3] Hatai, S., "On Limnodrilus Gotoi (n. sp.)," *Annotationes Zoologicae Japonesis.* Vol. iii, Part i, 1899.

[4] Hatai, S., "On Vermiculus limosus," *Annotationes Zoologicae Japonesis.* Vol. ii, Part iv, 1896.

somewhat polygonal, firmly connected, and possess comparatively small nuclei. (*b*) The cells of the central part are larger than the former, becoming gradually spheroid and more loosely connected; the nuclei are larger, and the peritoneal membrane of the testis disappears in this region. (*c*) At the free ends of the testis the cells present completely spherical forms, and are so loosely connected that they may be easily detached. The spermatogonia have conspicuous nuclei. Each fully matured spermatogonium has one large nucleus, and is not multinucleate, as in Lumbricus (Calkins).

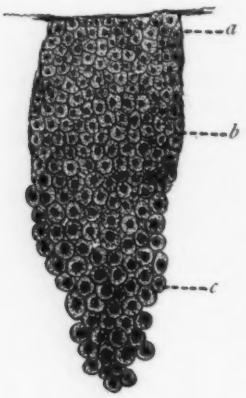

FIG. 1.

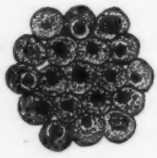

FIG. 2.

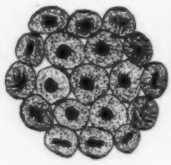

FIG 3.

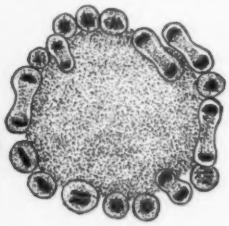

FIG. 4.

2. *Spermatocyte* (Figs. 2, 3). — The primordial germ-cells, or spermatogonia, when fully matured drop from the testis; sometimes one or two, but usually many at the same time, afterwards swelling up gradually. When they are first detached from the testis, no changes are noticeable, but with the beginning of cell division the following nuclear changes are observed: The nucleus of each cell in the outer layer moves inward toward the center of the cluster, as shown in Fig. 2. Each nuclear membrane disappears, while the chromosomes become distributed evenly throughout the nucleus. Soon the chromosomes collect in the equatorial plane (Fig. 3) and undergo division by the usual method of karyokinesis (Fig. 4). The spermatid arises after two or more such divisions. The cells at the central part show no signs of change, but remain in the resting stage.

Usually, after the peripheral cells have divided, the central cells become granular and appear homogeneous; the nuclei and cell membranes can no longer be distinguished (Fig. 5). In other words, the central cells degenerate at this period and become transformed into a cushion for the spermatozoa. This cushion is called the "sperm-blastophore" by Bloomfield.

FIG. 5.

FIG. 6.

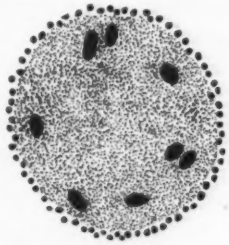

FIG. 7.

(Occasionally this transformation of the central cells occurs previous to the division of the peripheral cells, Fig. 6). The daughter-cells produced by the several divisions of the spermatocyte become half the size of the mother-cells, and retain this size throughout the stages of formation of the spermatozoan. These half-sized cells are the spermatids.

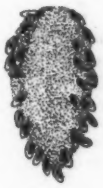

FIG. 8.

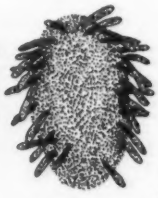

FIG. 9.

FIG. 10.

FIG. 11.

3. *Spermatids.*—The spermatids encircle the blastophore (Fig. 5), which changes to a spherical form and becomes more conspicuous than in the former stage. The spermatids now undergo repeated cell division, producing an enormous number of new spermatids (Fig. 7), which gradually elongate (Figs. 8, 9), and finally become tailed spermatozoa (Figs. 10, 11). The

tails of the spermatozoa all turn in one direction, as depicted in Figs. 10, 11. While these changes of the spermatids are in progress, the blastophore itself changes its form from spheroid to oblong and sometimes becomes spindle-shaped (Fig. 12).

As shown above, the central cells of the original cluster degenerate to form the sperm-blastophore, which appears as a homogeneous substance. It should be here stated that cases have been observed in which several nuclei were scattered through the homogeneous substance of the blastophore, but rarely a complete cell, as shown in Fig. 13. The question arises as to the origin of these nuclei or cells. It seems reasonable to suppose that they are simply belated portions which have not yet been transformed into the homogeneous mass. Fig. 7 shows a condition in which only the nuclei remain. At no time during the formation of the blastophore has a proliferation of the central cells been observed.

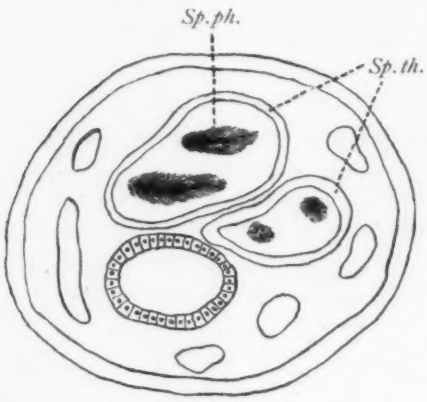

Fig. 12.

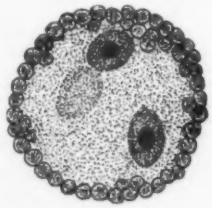

Fig. 13.

The spermatophore becomes slightly modified in passing from the sperm-sac to the spermatheca, as shown in Figs. 12, 14, 15. It is to be noticed that the tails of the spermatozoa turn spirally; this being a secondarily acquired character occasioned by its passage through the sperm-duct. Following these changes, the sperm-blastophore becomes more or less spindle-shaped; it also decreases in size. In the cross-section of a spermatophore a central canal is generally to be seen, as represented in Fig. 15. The blastophores are at first com-

paratively large (Figs. 8–11); they gradually decrease, and finally disappear, as shown in Fig. 15. It would appear, therefore, that the blastophore is produced by the degeneration of the central cells, and that it not only acts as a cushion, affording a means for conveying the spermatozoa, but also serves as nourishment for them.

Bloomfield's principal results, as briefly summarized by Calkins, are as follows:

"1. The early germ-cell is not entirely used in the formation of spermatozoa; a central part remains passive, and serves to carry the developing spermatic cells. This central part is called the sperm-blastophore, and may or may not be nucleated.

FIG. 14.

FIG. 15.

2. The sperm-blastophores increase by division while in the testis, and disappear, probably by atrophy, after the spermatozoa leave it.

3. The blastophore corresponds to the nucleated supporting cells (Sertoli's cells) of the frog and salamander.

4. The large nucleus of the early sperm-cell divides many times to form secondary nuclei, which stand out around the central mass, or blastophore, of the generating spheroid with very little protoplasm clothing them. These nuclei become the rod-like heads of the spermatozoa.

5. The protoplasm collects in a small cup, or knob-like mass, at the distal end of the developing cell, and from this grows out the long vibratile tail of the spermatozoan. (This 'mass' must be the archoplasm of the spermatid.)"

Calkins summarized his own results as follows:

"1. A multinucleated cell is formed in the testis; this represents a group of the earliest spermatic cells or spermatogonia. Each spermatogonium gives rise to several spermatozoa.

2. The nuclei arrange themselves around the periphery of the multinucleate cell; cytoplasmic cleavages then ensue between the nuclei, as in the centrolecithal egg. The cleavage grooves deepen until the nuclei are separated from the central mass of cytoplasm by mere filaments.

3. The residual mass of cytoplasm thus formed (the blastophore) is not nucleated, and cannot be compared with a Sertoli's cell in function, form, or mode of origin. It finally disappears. The blastophore furnishes perhaps the chief source of food supply for the parasites — monocysts — which live in the seminal vesicles. A possible explanation of the function of the blastophore is that of superfluous nutritive cytoplasm, the vital protoplasm having gathered around the nuclei."

Thus it will be seen that Bloomfield and Calkins hold very different views regarding the blastophore. The former considers it as having a nutritive or feeding function. It carries developed spermatozoa, and is to be regarded as the homologue of Sertoli's cell. The latter maintains that the blastophore is merely an excess of cytoplasm and not a true cell; therefore it cannot be homologous with the Sertoli cell.

The question as to the structure and function of the blastophore in Lumbricus can be decided only when we learn its true origin. In the present work on the two new species of Limicolae, it appears that the blastophore originates through the degeneration of certain of the primordial germ-cells which lie at the centers of the clusters of spermatogonia given off from the testes.

It serves not only for carrying developed spermatozoa, but for their nourishment as well. Thus it arises from *definite cells*, and, as Bloomfield has suggested, may be compared to the *Sertoli's cell.*

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PECULIAR TRACHEAL DILATATIONS IN BITTACOMORPHA CLAVIPES FABR.[1]

CHARLES THOMAS BRUES.

BITTACOMORPHA is a member of a very aberrant group of *Tipulidae*. In connection with two other genera it has been separated from the *Tipulidae* and considered as a distinct family. Of the genus *Bittacomorpha* only two species are known, both from North America. The species upon which these remarks are based is the commoner and more widely distributed form. It occurs from the New England states westward to the Pacific coast and has been taken as far south as Florida by Osten Sacken. In the northern states it is double brooded, and the imagines are seen during May and September, although much more commonly in the spring. The other species (*Sackenii*), which was described by Von Roeder in 1890,[2] is much more limited in its distribution and is recorded only from Nevada.

The common species (Fig. 3) is of the very slender form so characteristic of the *Tipulidae*. Its appearance is remarkable, however, on account of the peculiar black and white banding and the great inflation of the metatarsi of all the legs. The preparatory stages of a European species of the closely allied genus *Ptychoptera* have long been known, but it was only very recently that the larva and pupa of *Bittacomorpha clavipes* were discovered and figured by Hart.[3] The larva, like that of *Ptychoptera*, is aquatic, living among the submerged brushwood and sticks, which it resembles in color and external appearance. It is in this instar that we find the first peculiar modification of the tracheal system. The larva is furnished with an elon-

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, under the direction of Wm. M. Wheeler, *No. 3*.

[2] *Wiener Ent. Zeitung.* Heft 8, p. 230.

[3] *Bull. Illinois State Lab. Nat. Hist.* Vol. iv, p. 193.

gated breathing tube, produced by the excessive lengthening of the posterior end of the abdomen (Fig. 1). This formation is not peculiar to this species, as it occurs elsewhere, even in insects in nowise related, as in *Eristalis* among the *Syrphidae*. In the pupa we find a respiratory tube present, but in this instar its insertion is exactly reversed; it proceeds from the head. Although only one tube is functionally developed, it is one of a pair which has lengthened at the expense of its fellow (Fig. 2). Moreover, it is not always the same tube which is developed. Hart mentions that twenty-seven pupae had the right tube elongated as against three in which the left tube functioned. In one anomalous case both were developed, but unequally, their combined length being equal to that of the long one in normal pupae. This unequal length of the tubes is characteristic also of *Ptychoptera*.

Up to the present time it has not been known that the imago also possesses a remarkable modification of the tracheal system. In this stage, however, it is to be found in the legs.

In both sexes the metatarsi are very much enlarged and quite conspicuous on account of their great color contrast. The second and third tarsal joints are also somewhat enlarged, but not nearly to so great an extent.

In order to study the tracheal system of the legs they were decolorized in chlorine water and mounted whole or split into halves. Some specimens were treated also with potassium hydroxide, which successfully separated the delicate tracheae from the integument. Legs were also sectioned in paraffin to show the disposition of the internal parts.

In the basal part of the legs the tracheal tube is of the ordinary form and size. It begins to enlarge just before the middle of the femur, and before it has reached the tip is equal to seven-eighths the diameter of the femur. At this point the taenidia extend entirely around the tube, although faint in some places. The whole tibia is completely filled up by the trachea, which is striated on each side for only about one-fifteenth of its circumference. In the enlarged metatarsus the trachea is enormously distended and almost completely fills the cavity of this joint as well as that of the second and third

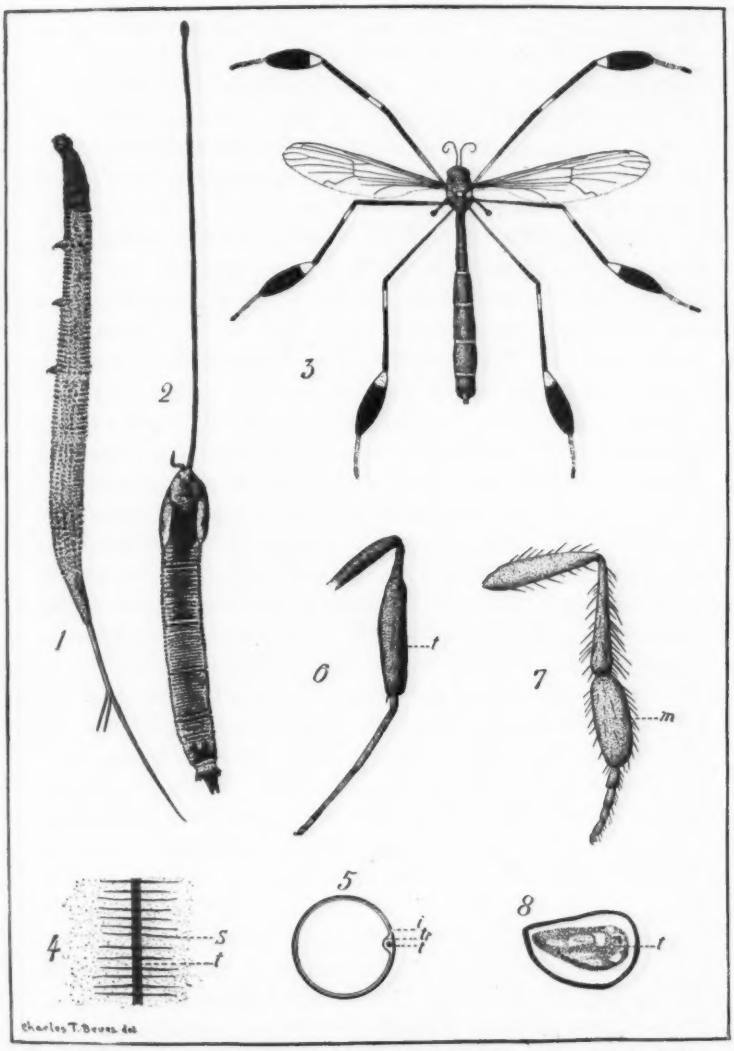

Fig. 1. Larva of *Bittacomorpha clavipes* (after Hart). — Fig. 2. Pupa of *Bittacomorpha clavipes* (after Hart). — Fig. 3. *Bittacomorpha clavipes*, in the position which it assumes when flying. — Fig. 4. Portion of tracheal wall of metatarsus of *Bittacomorpha*, showing position of tendon; *s*, taenidial striation; *t*, tendon. — Fig. 5. Diagrammatic cross-section of metatarsus of *Bittacomorpha*; *t*, tendon; *i*, chitin integument; *tr*, tracheal wall. — Fig. 6. Hind leg of *Pelecinus polyturator*, ♀; *t*, tibia. — Fig. 7. Foreleg of *Hilara trivittata*, ♂; *m*, metatarsus. — Fig. 8. Cross-section of metatarsus of *Hilara trivittata*, ♂; *t*, trachea.

joints of the tarsus. The wall of the trachea lies closely applied to the exoskeleton of the metatarsus, except for a very short distance on one side of the leg, where it is semicircularly bent inward to leave space for the claw tendon which lies in the tubular space thus formed (Fig. 5). Here as in the tibia the taenidia are visible on only about one-fifteenth of the circumference on each side.

The walls of the trachea are here not entirely destitute of taenidia, as is the case with the air vesicles which appear in the body cavities of many active insects. The striations have remained on that part of the tracheal wall which encloses the tendon (Fig. 4). At the point where the tendon passes, the taenidia are thickened and quite robust, but on each side they gradually become weak and fade out entirely. An exactly symmetrical formation of the taenidia is present on the side opposite to the tendon. It is evident that the thickenings on the tendon side may have been retained in order to strengthen the tube at this point, but there is apparently no reason for the anomalous thickening on the opposide side. In the second and third joints the taenidia lengthen until they extend over one-seventh of the circumference. The trachea seems to stop suddenly here, as I have been unable to trace it further.

There are few insects presenting similar enlargements of the leg joints, if we except those forms such as jumping *Orthoptera* and *Chrysomelidae*, where the increase in size is evidently for the accommodation of the larger muscles. Graber and Lubbock mention enlargements of the trachea in the tibiae of *Orthoptera*, ants and *Termitidae*, serving as auditory or chordotonal organs. In this case the adaptation is very extraordinary, but the dilatation of the trachea is not comparable to that of *Bittacomorpha* in extent. *Bittacomorpha* presents the only case known to me of a considerable tracheal dilatation occurring in the insect leg. In the males of many *Empididae*, and notably species of *Hilara*, e.g., *Hilara trivittata* Lw., the metatarsus of the front leg is greatly enlarged (Fig. 7), but here the cavity is occupied in great part by muscular tissue, the trachea being very slender (Fig. 8). In this species there seems to be no trachea beyond the end of the metatarsus.

In the legs of normal *Tipulidae* (*Pachyrrhina* sp.? and several other species) the trachea occupies a considerable space only in the femur and tibia, where it fills up from one-fourth to one-sixteenth of the cavity. In the tarsus the tracheal tube is very delicate or obsolete.

The female of the peculiar parasitic hymenopteron, *Pelecinus polyturator* Drury, presents an external appearance similar to that of *Bittacomorpha* in the enlarged hind tibia (Fig. 6). Here, however, the chitin of the external wall is thick and heavy, and the trachea is robust, strongly striated, but not at all dilated.

It is the rule in insects, wherever a tracheal dilation occurs, that the taenidia become obsolete, but the thinning of the tracheal wall can nearly always be regarded as a modification for the purpose of offering less resistance to osmosis. This is illustrated by the air vesicles in the bodies of insects, which are generally considered to be reservoirs for storing air to be used during extended muscular exertion. The presence of these immense vesicles in the metatarsi cannot be explained on the same principles, for it is impossible that they should serve as reservoirs for air to be used in respiration, on account of their distance from the body of the insect. It is more probable that they may bear some relation to the insect's method of locomotion. When flying, *Bittacomorpha* uses the wings scarcely at all, relying in great measure upon wind currents for transportation. The legs are exceedingly light, as the exoskeleton is thin and delicate, and encloses practically no tissue which can serve to increase their weight. As they expose a large surface, they offer great resistance to the air without adding appreciably to the insect's weight.

Drifting along thus, their extremely slender bodies and white banded appendages give them a most peculiar, intangible appearance, which is heightened by their extremely slow motion.

When examined in the cabinet, the conspicuous white and black banding of *Bittacomorpha* seems to point toward a case of warning coloration. When they are seen against their natural background, however, all these brilliant contrasts fade away into a perfectly neutral color which causes them to resem-

ble a spider's web or thistle seed drifting along. Indeed, when I first saw them it was hard to believe that they were really alive. *Bittacomorpha* seems to have developed its protective coloration along the same lines as the zebra among the vertebrates; it is rendered invisible not only by the fragmentary distribution of color, but by the neutral gray color produced by the visual blending of the black and white.

From the description of *Bittacomorpha Sackenii* by Von Roeder, it seems that this species does not possess any dilatation of the metatarsi. It would be very interesting to see if there is any abnormal development of the tracheal system in this species, but unfortunately I have been unable to procure specimens. The specimens examined were given to me by Dr. Wm. M. Wheeler, to whom I feel greatly indebted for many kind suggestions.

LAMPREYS IN CAPTIVITY.

ALBERT M. REESE.

HAVING had living lampreys of various ages under observation in the biological laboratory of Johns Hopkins University, I present the following facts as to the ability of these animals to live in a very limited space.

I received, about the middle of May, from Ithaca, N. Y., two lots of lamprey eggs, about six dozen eggs in each lot. They were shipped by express and must have been on the road about twenty to twenty-four hours. They had been shoveled out of the "nest," with about 2 l. of gravel, and put into two tin buckets of 8 l. capacity. The space in the buckets above the gravel was filled with water, and in one of the buckets were some three dozen larval lampreys ranging from 2 cm. to 12 cm. in length. None of these eggs developed, although they were put into running water as soon as they reached the laboratory.

My experience with the small larvae (about 5 mm. in length) was more successful. I obtained one hundred or more of these from a stream at Ithaca, and brought them to Baltimore in two glass jars of 3–4 l. capacity each. A small quantity of gravel was placed in the bottom of each jar for the larvae to bury themselves in, and the water was kept cool by partially emptying the jars from time to time, and refilling them with ice water from the coolers on the train. The journey lasted for about eighteen hours, and all the larvae, except three or four, reached the laboratory in good condition.

The small amount of sediment in the city water proving disastrous to the welfare of the larvae, clear spring water was obtained every few days, and this was kept cool by allowing the jars to stand in larger vessels of running water. Even with this arrangement the deaths averaged one per day, and about the first of August the remaining larvae were killed and

preserved, after having, with difficulty, been kept alive for six weeks.

The older larvae which were received, as has been said, in one of the buckets containing eggs, proved to be very hardy, and five or six of them were kept in a 12 l. aquarium for six months or more without the least difficulty. At the end of this time they were killed, two of them having shortly before (October 20) transformed into the adult Petromyzon branchialis. During their entire captivity they remained completely buried in the sand in the aquarium. A small stream of water was kept running through the aquarium, though a *constant* change of water was not necessary.

In the early part of April, I brought from the herring fisheries at Port Deposit, Md., five large sea lampreys (P. marinus) in two tin buckets, each bucket of about 50 l. capacity. Being nearly a meter in length and about 12 cm. in circumference, the five lampreys were rather crowded in the two buckets, and only four of them survived the three-hour journey to the laboratory. They were put into an aquarium (1.5 m. × .8 m. × 12 cm.) of running water, where they lived comfortably for several weeks, until by accident the wire screen was left off the aquarium, and three of them escaped and were found dead upon the floor. On June 22 the remaining lamprey was killed. It proved to be a female, and 250 cc. of ripe ova were "stripped" from her with ease. Had one of the males been kept alive it seems probable that artificial fertilization could easily have been accomplished.

To sum up, then, it seems (1) that the very small larvae are very delicate and hard to keep in confinement; (2) that the large larvae are unusually hardy; and (3) that the adults are able to live in captivity moderately well.

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